Name_____

Precipitation Reactions Lab

Introduction

Wastewater treatment often involves precipitation reactions. Heavy metal contaminants, like lead ions, can be simply removed from the water supply using a solution of sodium chloride. In the water treatment facility, the following reaction takes place:

$$Pb(NO_3)_{2(aq)} + 2NaCl_{(aq)} \rightarrow PbCl_{2(s)} + 2NaNO_{3(aq)}$$

In this **formula equation,** the insoluble lead (II) chloride precipitate falls to the bottom of the containment tank and the water is rid of any harmful ions.

A **double replacement reaction** usually takes place between two ionic compounds that are dissolved in water. The cation of one compound replaces the cation of the other to produce two new compounds. The new combination of cations and anions yields a product that may be a precipitate, a gas, or water. One of these must form for the reaction to actually take place. Precipitates are solids that form from the reaction between compounds that are soluble in water.

To further analyze precipitation reactions, we can look more in depth at what is going on in the test tube. Ionic compounds **dissociate** in water. This means that the ions of a compound break apart from one another and float freely around the solution. This is why you often see bottles labeled with only one ion on them, like in the flame test lab. Since we only cared about the metal cations in that lab, the bottles were labeled with those ions and the anions were ignored. For example, Na^+ appeared on the label, not $NaNO_3$. The dissociation of an ionic compound when it dissolves in water and becomes aqueous can be written in the following reaction:

$$Pb(NO_3)_{2(aq)} \rightarrow Pb^{2+}_{(aq)} + 2NO_3^-{}_{(aq)}$$

Precipitates are not dissolved in water, and therefore do not dissociate in water like the soluble compound shown above. Now if we look at all the reactants and products above, we can show a balanced equation that depicts each soluble compound as its respective ions. If we take the lead (II) chloride precipitation reaction and write each soluble compound as its ions it would look like this:

$$Pb^{2+}_{(aq)} + 2NO_3^-{}_{(aq)} + 2Na^+_{(aq)} + 2Cl^-_{(aq)} \rightarrow PbCl_{2(s)} + 2Na^+_{(aq)} + 2NO_3^-{}_{(aq)}$$

This reaction above is called an **ionic equation**. All of the soluble ionic compounds are separated into their respective ions. Now you may look at this reaction above and see that some ions do not change. The sodium and the nitrate are the same on both sides of the yield sign and do not combine. They are called **spectator ions**. This means they are in the presence of a chemical reaction and are NOT actually involved in a chemical reaction. They are just there to balance the charge of the other cations and anions. If we remove them we get the following reaction:

$$Pb^{2+}_{(aq)} + 2Cl^-_{(aq)} \rightarrow PbCl_{2(s)}$$

This is called the **net ionic equation**, and it shows the real reaction that is taking place. The lead (II) ions combine with the chloride ions and form an insoluble precipitate.

In this investigation you will mix several pairs of aqueous solutions of ionic compounds. You will observe which combinations of solutions result in the formation of a precipitate, and you will write balanced formula equations and net ionic equations for the reactions that took place.

Materials

Goggles	0.1 *M* $AgNO_3$	0.1 *M* $Fe(NO_3)_3$	0.1 *M* $Cu(NO_3)_2$	
Overhead Transparency	0.1 *M* Na_3PO_4	0.1 *M* Na_2SO_4	0.1*M* NaOH	0.1 *M* NaCl

Procedures

1. Obtain an overhead transparency. On the transparency, place **2 drops** of $AgNO_3$ in four spots in one row on the plastic sheet. Do the same for the $Fe(NO_3)_3$ and $Cu(NO_3)_2$ below the previous row of $AgNO_3$.

2. Now drop Na_3PO_4 down the first column of solutions from step 1. Repeat for the other solutions.

YOU ARE COMBINING SOLUTIONS IN THE ORDER THEY APPEAR IN THE TABLE BELOW. YOU HAVE DONE THIS TECHNIQUE IN OTHER LABS

3. In the data table below, indicate in each box where a solution combination produced a precipitate.

Data

Ionic Solutions	Na_3PO_4	Na_2SO_4	NaOH	NaCl
$AgNO_3$				
$Fe(NO_3)_3$				
$Cu(NO_3)_2$				

Questions *(answer the following questions on a separate sheet of paper)*

1. For which combinations of solutions did no precipitate form? Based on these observations, which compounds are soluble in water? Explain.

2. Based on your observations, which positive ion reacts to form the greatest number of precipitates: Ag^+, Fe^{3+}, or Cu^{2+}? Explain.

3. Use a solubility table to determine the identity of the precipitates that formed in the wells in the first column of the data table. Then write balanced equations for these reactions, *including* the symbols for phase, (s) and (aq).

4. Writing net ionic equations.
   a. Write the formula equation for the reaction that takes place when a solution of silver nitrate is added to a solution of sodium chloride.
   b. Write the soluble reactants as ions.
   c. Write the products with respect to their solubilities. (Remember aqueous compounds dissociate and insoluble compounds do not.)
   d. Combine your answers from b and c into an **ionic equation**.
   e. Which ions are present at the beginning and the end of the reaction? What are these ions called?
   f. Write a net ionic equation for this reaction.

5. Sodium hydrogen carbonate and sodium chloride are both soluble in water. Will a double replacement reaction take place if a solution of sodium hydrogen carbonate is added to a solution of sodium chloride? Explain.